reduces both the received carrier-to-noise ratio and the clear-sky margin, thereby reducing availability performance.

DBS operators have invested in expensive high power satellites to establish critical link margins to offset most rain-induced degradation. Adequate clear-sky margin must be maintained in order to provide high quality and robust service to DBS customers.

In practice, it is not possible to design a system that is capable of compensating for all rain-induced conditions. Dominant factors affecting availability in a particular reception area are rain attenuation of the downlink signal and rain-induced increase in system noise temperature. Added interference via NGSO- or Northpoint-generated noise reduces the DBS overall system received carrier-to-noise power ratio (C/(N) to C'/(N'+I)), where C' and N' are the carrier and noise levels during a rain event, respectively, and I is the interference. Note that C'<C and N'>N both combine to reduce the carrier-to-noise ratio. Added interference reduces the clear-sky margin, thereby further reducing the system's overall capability to offset rain events. Reduction in received carrier-to-noise ratio manifests itself as degradation, or worsening, of the BSS system's availability. As described in Section 3.4, DIRECTV has demonstrated that even small decreases in carrier-to-noise ratio result in significant reduction in BSS system availability.

The reduction in availability with interference present, or alternatively, the percentage increase in unavailability, provides a clear measure of the impact of interference on BSS system performance. Change in availability is calculated by comparing the service's availability both with and without Northpoint interference. Appendix A, Table 2 provides a link budget for DBS service to Washington, D.C. from the DIRECTV satellite at 101° W.L. In this link budget, the ITU protection criteria for limiting the DBS availability was applied to the DIRECTV link in Washington, D.C.

Two different examples were generated using the ITU protection criteria.

In the first, a maximum unavailability degradation of 2.86% was used as the protection criterion. This corresponds to the estimated increase in unavailability that could be produced by *one* NGSO-FSS system. This criterion results in a clear-sky C/I of 27.2 dB. This equivalent steady state interference value is used later in this report to analyze the size of interference zones surrounding Northpoint transmitter sites.

In the second, a maximum unavailability degradation of 10.0% was used as the protection criterion. This corresponds to the maximum increase in unavailability that could be produced by *all* NGSO-FSS systems. This criterion results in a clear-sky C/I of 21.9 dB. This equivalent steady state interference value is also used later in this report to analyze the size of interference zones surrounding Northpoint transmitter sites.

In general, there is a relationship between received C/I ratio and the resulting degradation in unavailability. This relationship is shown in Figure 3.2-1. The two cases discussed above are shown as large points at 10% and 2.86% unavailability degradation.

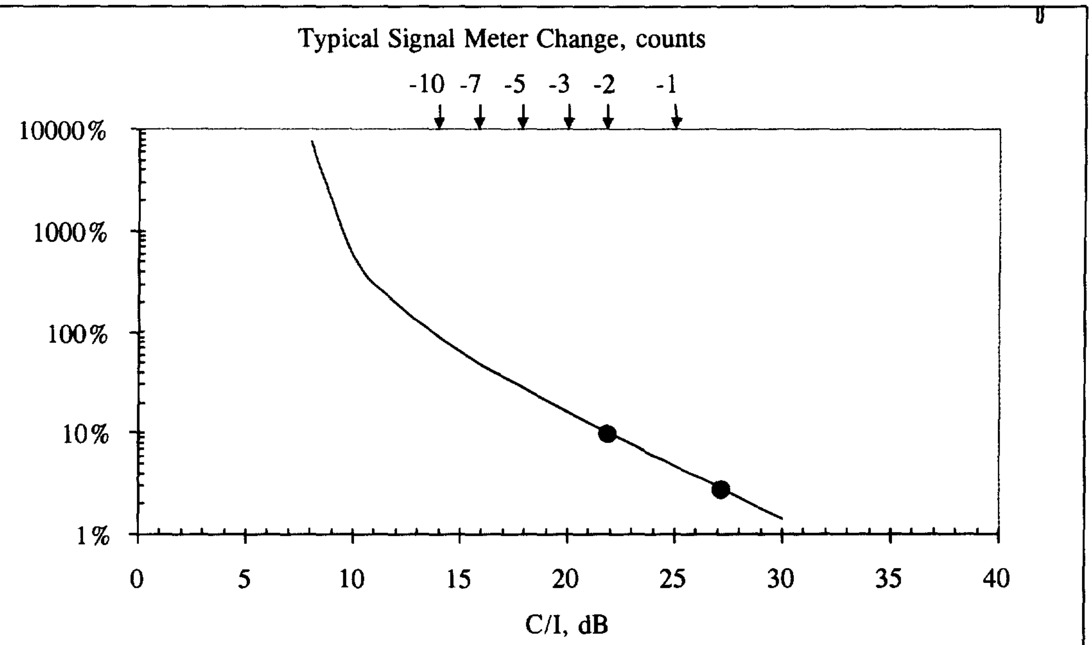

Figure 3.2-1:
Relationship Between C/I, Degradation and the Signal Meter

Note that this figure also shows typical signal meter changes that can be expected when interference is first introduced. Interference at the limit allowed for all NGSO-FSS systems is indicated when the signal meter decreases by approximately 2 counts.

Note also that this change can be best thought of as a constant difference in signal meter reading between that measured in the interference-free environment and that measured in the interference-present environment. The signal meter normally varies with time due primarily to changes in atmospheric propagation. With interference, the signal meter readings will have the same profile over time as would be measured with no interference, but will be depressed in proportion to the amount of interference. This lower profile indicates a loss in clear-sky margin, and increased sensitivity to rain fade conditions. Examples of this phenomenon can be seen in Figures 3.4.1.1-1 and 3.4.1.2-1.

Thus:

- adding interference from NGSO or Northpoint systems degrades received carrier-to-noise ratio;

- this reduces clear-sky margin, and degrades availability performance;

- such reductions can be measured by the signal meter in the IRD; and

- constant depression of signal meter readings by 1 to 3 counts due to interference is very significant.

3.3 *Discussion of Quasi-Error Free Operation and Rain Fade Margin*

Northpoint has asserted that harmful interference only occurs when the interference forces the received carrier-to-noise ratio to near or below threshold levels (where the Bit Error Rate ("BER") is suddenly reduced) under clear-sky conditions.[10] This is not accurate. As discussed in Section 3.2, much smaller reductions in received carrier-to-noise ratio manifests themselves as loss of link margin, or system availability, and are indeed quite harmful. This can be illustrated as follows:

Figure 3.3-1 again illustrates the signal meter versus carrier-to-noise performance curve for a typical BSS receiver. In the example shown in this figure, a typical received carrier-to-noise (C/N) ratio is set at 13.0 dB (Point A). For the given C/N of 13.0 dB, an equivalent signal strength value is 90.

Now, we assume that interference is added to the signal in an amount equivalent to a C/I ratio of 10 dB. Note that the signal meter will be reduced by thirty counts (from 90 to about 60 – from point C to D) as the carrier-to-noise ratio is reduced from C/N = 13 dB to C/(N+I) = 8.24 dB (from point A to B). Note, however, that the link is still operating in what is called the quasi-error free zone. In this zone, the bit stream produced by the forward error correction circuits is still virtually error free because of the very strong error correction feature designed into the digital DBS link.

This feature is designed to protect the reception quality of the signal under transient minor to moderate rain fade conditions, and it does so very well. If, however, the forward error correction ("FEC") circuits need to correct errors caused by this amount of long-term interference, then there would be little margin left to combat the minor to moderate rain fade conditions for which they were designed. The consequences of this are clearly illustrated in Section 3.4.

[10] Northpoint Experimental D.C. Report at 4 ("In previous Northpoint Technology experimental work in Kingsville, it was documented that 4.8 dB was the critical C/I ratio in which Northpoint's signal could cause harmful interference to DBS.").

To continue with this example, Figure 3.2-1 shows that a C/I of 10 dB would cause a very dramatic 350% degradation in unavailability or a 3.5 fold increase in annual outage time. Thus, although still operating in the quasi-error free zone where there are no measurable changes in FEC output bit error rate, the added interference has clearly had a very harmful effect.

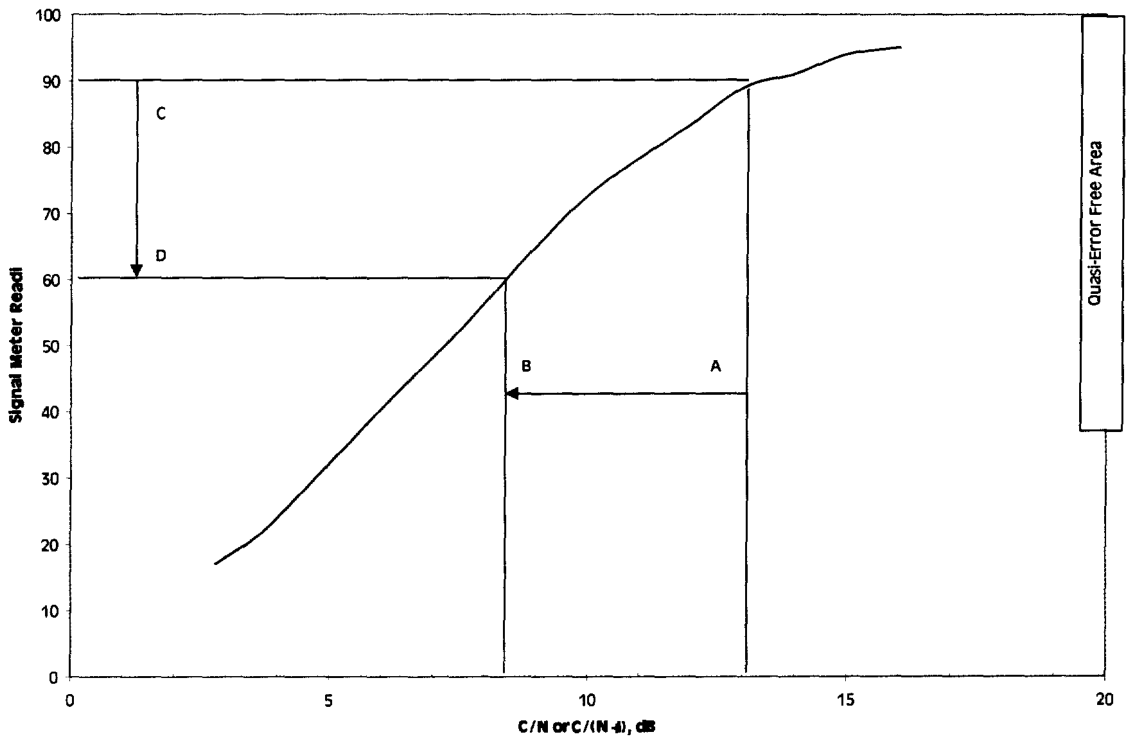

Figure 3.3 -1: Typical Signal Strength versus Carrier-to-noise Performance

3.4 *Demonstrated Loss of Availability Performance*

To clearly establish that the addition of interference degrades availability performance, DIRECTV set up a well-controlled test demonstration in Spring Creek, New York. In this test, two identical receivers were fed the same satellite signal from an external antenna. One receiver, however, received an extra amount of interfering noise. The effect on rain fade performance was then carefully recorded over a three-month period.

This experiment clearly demonstrated the following effects:

- when interference is present, a DBS digital receiver suffers longer rain outages when compared to its interference-free performance;

- a DBS receiver with external inference will recover from a rain fade induced loss of service later than a receiver with no interference.

3.4.1 New York Rain Demonstration Conducted by DIRECTV

Figure 3.4.1-1 shows the equipment block diagram used in DIRECTV's New York rain measurements. A single DBS antenna/LNB was used to receive the DBS signal at 101° W.L. Two identical DBS consumer integrated receiver decoders were set up to process the received signal, one without interference (IRD1) and one with interference (IRD2). Test subscriber A receiver (IRD1) was identical to test subscriber B receiver (IRD2), with the exception that test subscriber B receiver was injected with interference.

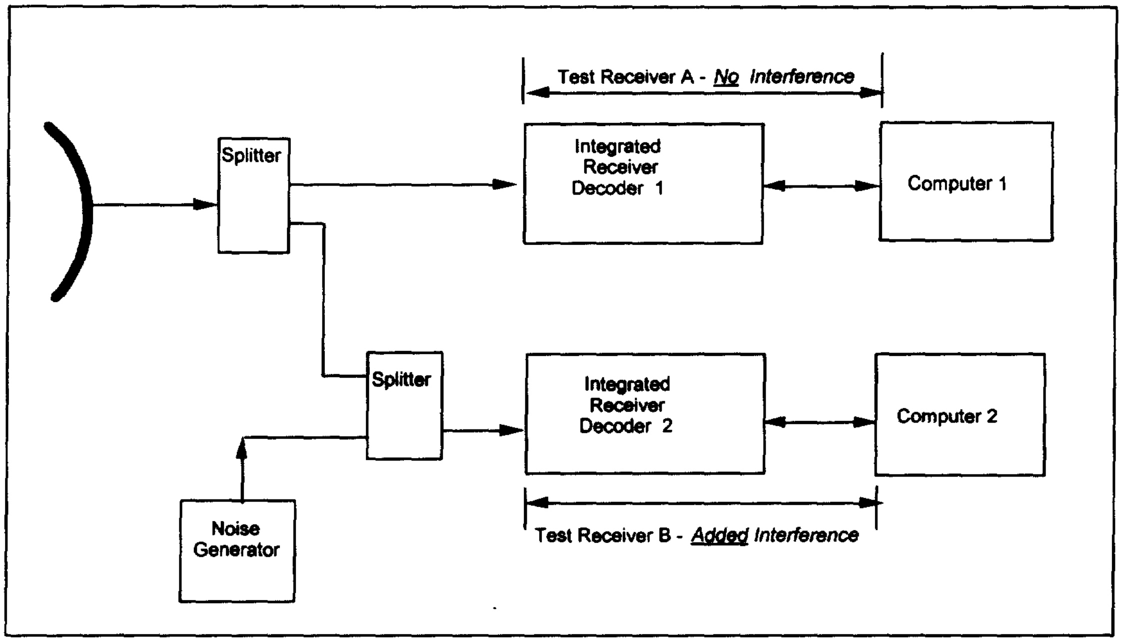

Figure 3.4.1-1: DIRECTV Interference Simulation Block Diagram

Signal meter data with and without interference were then collected from August 4 to November 30, 1999. A detailed calibration was performed on the two identical IRDs to be used in the test. Detailed verification of the measured input levels into each test IRD and a careful measurement of the LNB noise floor were then performed.

Two different interference levels were used during this test period. The first interference level was at a severe C/I value of 8 dB to clearly establish the phenomenon. The second interference level, adopted in the later part of the test period, was at a C/I level close to the recorded interference levels observed at the Ericsson Memorial/Polo Field site by DIRECTV during Northpoint's demonstration in the Washington, D.C. area.

As described earlier, the BSS receiver signal meter was used to detect the change in carrier-to-noise ratio with and without interference, as well as to detect when service had been lost due to the combination of rain and interference. These receiver signal meters were carefully calibrated. The calibration curves for test receiver A (IRD1) and test receiver B (IRD2) are shown in Figure 3.4.1-2. This test was performed using a high information code rate.

In this experiment, the interfering signal level is held constant throughout the test period, including through rain events. Any attempts to fade the interference would have certainly been very difficult and also quite subjective. Any given rain event will fade the satellite signal and the interfering signal by differing amounts, with no rain event behaving exactly the same as another. Because the path length to the satellite will typically be longer than the path length to the Northpoint transmitter, it is expected that the fade along the interference path will be less than the fade along the satellite transmission path. Thus, the approach of not fading the interference in this experiment is well justified.

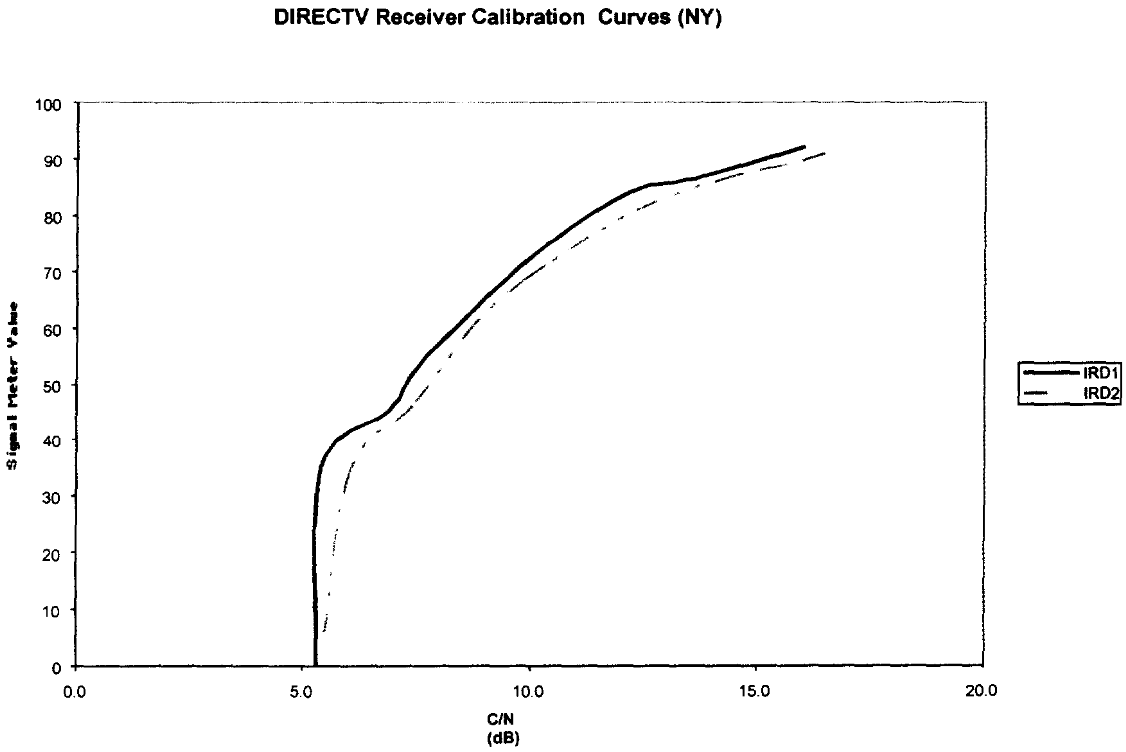

Figure 3.4.1-2 DBS receiver Calibration Curves (Spring Creek, NY)

Rain events are variable in nature, and no two events are ever the same. It is therefore important to examine a number of rain events to see how the receivers behave in the presence of interference. The following two sections describe two typical rain events that occurred during this test period. The impact of the rain on these two receivers is then analyzed.

3.4.1.1 New York Rain Event of August 26, 1999

Figure 3.4.1.1-1 shows the results of a rain event on August 26, 1999. The figure presents signal meter readings as a function of time (time of day). Prior to this event, the C/I had been set at an initial value of 10.6 dB. From observations of the clear-sky signal meter readings and from the calibration figures for this receiver, it appears however that the C/I ratio was near 8 dB on this particular day.

First, note the dramatic difference in the normal (no rain) signal level between receiver signal A and B at around 3:00. Receiver B, obviously the one suffering from added interference, has a nominal level of about 45 to 48 signal meter counts, while Receiver A shows nominal readings near 90.

It is also important to notice that both receivers are still operating in the quasi-error free region. Specifically, the forward error correction circuits in Receiver B are able to correct the very significant number of errors now being generated in the received bit stream by the added interference. The subscriber is receiving a clear picture – but the forward error correction circuits are under heavy stress.[11] Any further reduction in the clear-sky margin (such as that caused by even a minor rain fade) will cause errors to begin to appear at the output of the forward error correction circuits. They will have run out of margin.

Now, notice the effect when the first rain fade event occurs near 4:15. Receiver A successfully weathers this rain fade event because the carrier-to-noise ratio, and hence the signal meter, do not drop below the threshold level near 34 counts. Subscriber A would not have seen any effects of this rain fade because operation was still in the quasi-error free zone, and the forward error correction circuits of the receiver were able to correct the additional errors generated by the reduction in received carrier-to-noise ratio. To repeat, the built-in clear-sky margin (headroom above threshold) allows reception through this rain fade event, maintaining good availability.

Receiver B, on the other hand, quickly sees the carrier-to-noise ratio (and consequently the signal meter) fall below threshold for this same rain event. The forward error correction circuits are unable to cope with the additional errors, and *the picture was completely lost for 90-100 minutes.* To repeat yet again, the loss of clear-sky margin has caused harmful interference, resulting in extremely poor availability performance.

[11] For this reason, bit error rate testing (to which Northpoint on occasion has attempted to attach some significance) is meaningless for a determination of interference levels – Receiver B is clearly under stress and has lost significant performance capability, and yet the measured output bit error rate of the forward error correction circuits will show a high quality output.

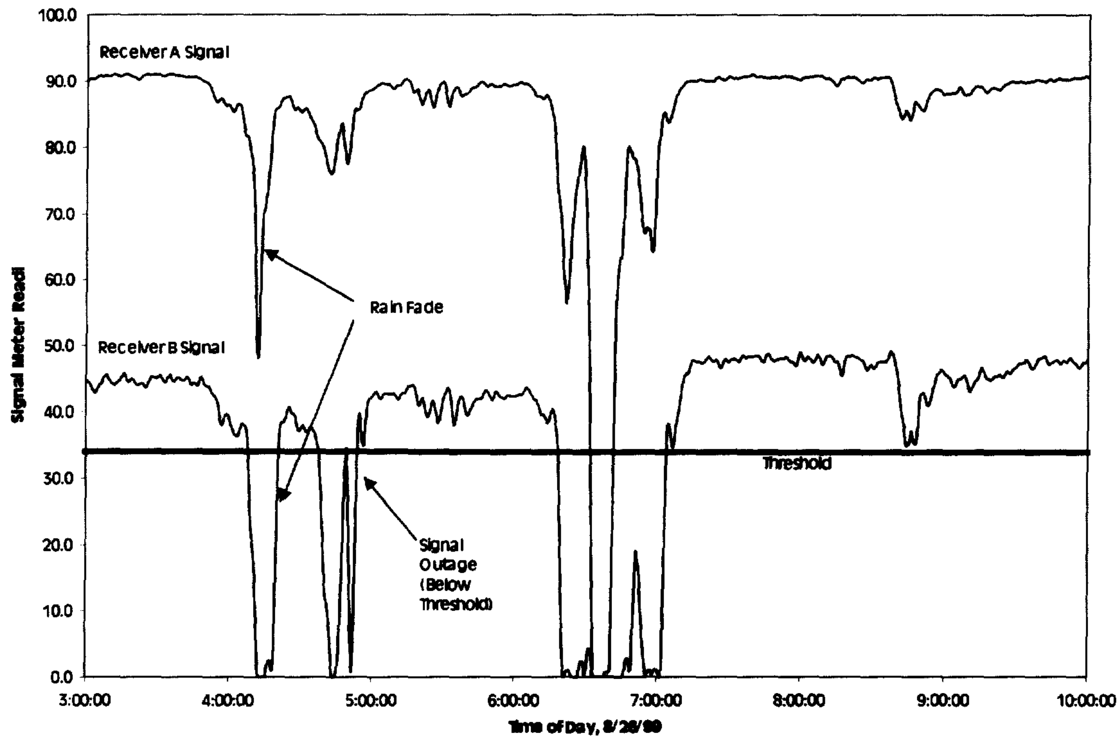

Figure 3.4.1.1-1: New York Rain Event, August 26, 1999

Later the same day, the rain rate reaches a sufficiently high level to cause even Receiver A to lose lock. This occurs near 6:30 on the time line. Note, however, that Receiver B with its significantly reduced clear-sky margin loses lock much earlier than Receiver A, and recovers much later.

In summary, Receiver B has suffered both more frequent and longer rain outages than Receiver A because of the added interference.

3.4.1.2 New York Rain Event of October 4, 1999

After a clear case of interference was observed at the Ericsson Memorial/Polo Field site in the Northpoint Washington, D.C. demonstration, DIRECTV went to its New York site with the goal of testing a similar interference level in rain conditions. The C/I level of the New York test equipment was set at 16.6 dB under clear-sky conditions (slightly higher than the C/I of 16 dB measured at the Ericsson Memorial / Polo Field site in Washington, D.C.). Results from one rain event after this interference level readjustment are discussed below and shown in Figure 3.4.1.2-1.

A problem arises because the frequencies allocated to NGSOs by WRC-97 Resolution 538 include the full 500 MHz downlink band used by BSS systems serving the United States. WRC-97, recognizing that great care must be taken to limit the interference introduced by the new NGSO systems into existing services, formed Joint Task Group 4-9-11 to first evaluate the provisional interference limits set by WRC-97 and then make suggestions to the next World Radiocommunication Conference as to how the provisional limits might be adjusted.

Since NGSO satellites move relative to GSO earth stations, new tools were needed to calculate how time-varying NGSO interference affects the availability of BSS systems. (Once again, availability is the time, usually expressed as a percentage, for which a service is available to its subscribers.) To accomplish this, DIRECTV developed one of the two computer programs generally accepted by JTG 4-9-11 for calculating the impact of NGSO interference on BSS system availability; the other computer program was developed by SkyBridge, one of the new NGSO system operators.

However, the BSS protection criteria needed to be refined before interference protection limits could be developed. Of specific importance was the fact that the interference would vary with earth station location and pointing direction, and with time. To develop these criteria, numerous analyses were performed. One US contribution to JWP 10-11S, authored by DIRECTV and entitled "Preliminary analysis toward using service availability degradation as a Broadcasting-Satellite Service protection criterion" (ITU document 10-11S/89), demonstrated that a protection criterion based on BSS system availability degradation is consistent with interference protection criteria in the Radio Regulations for constant interference sources. On the basis of this and other studies, JWP 10-11S, in the form of a draft new Recommendation, established two essential protection criteria: the first criterion is that interference from all NGSO systems will increase the existing or operational unavailability of BSS systems by at most 10%, and the second is that under clear-sky conditions, NGSO interference alone will not interrupt BSS services.

The maximum unavailability increase of 10% was arrived at by the ITU-R only after numerous discussions, tremendous effort and rigorous technical analysis. It represents a compromise between the service degradation that will be experienced by BSS systems and the operational restrictions placed on NGSO system operators. Note that the 10% degradation in unavailability criterion is calculated relative to the existing or operational unavailability. This is because the operational level of unavailability is the *de facto* quality of service level that has been enjoyed and established in the years since the deployment of digital BSS systems.

NGSO interference limits that conform to these two criteria were developed by the ITU-R for BSS antenna sizes up to 2.4 meters in diameter. The limits that apply to a single NGSO system are based on an "effective" number of NGSO systems of 3.5; and therefore the maximum increase in BSS system unavailability from one NGSO system is 2.86% (or 10/3.5%). Participants at the November 1999 ITU Conference Preparatory meeting agreed to these single-entry limits and aggregate interference protection, and they will be passed to WRC 2000 for final consideration and approval. These interference limits place operational restrictions on the NGSO operators — for example, some NGSOs will adhere to a non-operating zone near the geosynchronous arc to prevent interference from their main antenna beam from entering the main beam of a victim GSO earth station. It should be noted that these are restrictions that NGSO operators state they can meet while also providing two-way communication services to, potentially, many thousands of customers.

4.2 *DIRECTV Concludes Protection Criteria Must Be Applicable to Proposed Northpoint Operation*

The work performed to date at the ITU by regulators and the satellite industry establishes technical standards on the protection of unavailability. Performance in rain (low unavailability) is critical to DBS service quality and competitiveness. All NGSO systems must adhere to these new standards, which were reluctantly agreed to by the DBS industry. **This 10% limit on unavailability degradation must apply to the aggregate of all NGSO-FSS and Northpoint interference to DBS in the band, and it must protect all subscribers located throughout the DBS service area.**

Northpoint would have the Commission believe that these criteria developed for NGSO systems are not applicable. However, a DBS receiver cannot distinguish between NGSO-FSS interference and Northpoint interference. The criteria are both applicable and appropriate, and must be applied to the proposed Northpoint system operations in determining the existence of harmful interference.

5 *Interference Levels Measured in Washington, D.C. Area*

This section provides the results of interference measurements conducted by DIRECTV during the Northpoint demonstration in the Washington, D.C. area. The general test methodology used by DIRECTV during the Northpoint demonstration is detailed in Section 5.2. Section 5.3 details the measured interference into DIRECTV BSS receivers receiving signals from 101° W.L. Section 5.4 summarizes the measured interference into Echostar BSS receivers at 61.5° W.L. A comparison of DIRECTV field measurements with analytical predictions are detailed in Section 5.5.

5.1 *Summary of Findings*

DIRECTV made a significant effort, in spite of numerous impediments, to observe interference into DBS receivers during the Northpoint demonstration in the Washington, D.C. area. Observations were made on Northpoint signals interfering with reception from the then active DBS satellites located at 61.5°, 101°, and 119° W.L.[16]

It is important to note that critical Northpoint test parameters such as transmit power, antenna beam tilt and pointing direction of the Northpoint antenna mainbeam were not independently verified. Further, many desirable test sites were inaccessible.

Primarily, DIRECTV interference measurements were focused on two active DBS satellites located at 101° and 61.5° W.L. due to the planned Northpoint transmit antenna mainbeam direction of 113° azimuth. Interference into 119° was not as likely due to the Northpoint transmitter pointing direction and hence, DIRECTV did not perform extensive interference measurements into this orbital slot.

DIRECTV's measurement results conclusively demonstrate degraded DBS system performance due to Northpoint transmissions in the Washington, D.C. area:

1) Interference into DIRECTV was observed at the Iwo Jima Memorial site, approximately 0.6 kilometers south of the Northpoint USA Today transmit site. At this site, a reduction in the BSS receiver signal strength meter of three counts was observed, which resulted in an approximate 15% increase in DIRECTV's system unavailability. This unacceptable degradation of DBS system performance is higher than the 10% aggregate interference allowed for all NGSO-FSS systems.

2) Interference into the Echostar DBS system was observed at the Ericsson Memorial/Shoreline site, an area approximately 2.7 kilometers southeast of the Northpoint USA Today transmit site. At this site, a reduction in the BSS receiver signal meter of three counts was observed. Added interference due to transmissions from the strength Northpoint transmitter resulted in a reduction in Echostar's system unavailability of approximately 13%.

3) Further, interference into Echostar was also observed at the Ericsson Memorial/Polo Field site, an area approximately 2.3 kilometers southeast of Northpoint's USA Today transmitter. A change in the BSS receiver signal strength meter of eight counts, due to Northpoint interference, resulted in a reduction in Echostar's system availability of approximately

[16] In the time since the demonstration ended, DBS satellites have been active at 110° W.L. and 92° W.L.

84%.[17] In both cases, this reduction in Echostar's system performance is higher than the 10% aggregate interference allowed for all NGSO-FSS systems.

4) DIRECTV's analytical interference predictions showed reasonable correlation to the measured data from the Northpoint tests. However, it was not possible to draw firm conclusions due to multiple unverifiable Northpoint key parameters.

5) DIRECTV and Northpoint measurements indicate somewhat reasonable agreement in the measured interference data collected at several sites. However, some data discrepancies remain.

5.2 *General Test Methodology*

DIRECTV conducted a visual inspection of numerous sites in the D.C. metropolitan area in order to identify accessible sites close to the Northpoint transmitter. Many sites close to the transmitter were inaccessible or subject to blocking by unusually tall buildings where there was neither any Northpoint coverage nor detected interference.

Areas farther from the transmitter, as admitted by Northpoint, were "primarily uninhabited"[18] and also in many cases not accessible. It would have been valuable to obtain interference data from these locations, because in the general case of the siting of a Northpoint transmitter, even in the Washington, D.C. area, it would not always be possible for Northpoint to take advantage of rivers and parkland and still provide service in inhabited areas. Northpoint has yet to produce a proposed plan for all sites in a region, including the Washington, D.C. region.

DIRECTV's test methodology was to measure and record changes in the DBS receiver signal strength meter during Northpoint transmission when the DBS system was both shielded from Northpoint transmissions and unshielded. The signal meter readings were recorded for both Echostar and DIRECTV DBS systems in the presence of Northpoint 's transmissions. Two signal meter observation cases are defined herein as follows: "Transmit On" (Unshielded) and "Transmit On" (Shielded). Although the Northpoint transmitter was still on in the shielded configuration, the DBS antenna/LNB was completely shielded from the Northpoint transmitter. This was accomplished with aluminum material in order to provide effective blockage of the Northpoint transmit signal.

[17] Echostar Preliminary Report at 7.

[18] Northpoint Experimental D.C. Report at 5.

The test procedures at every site, as defined in the DIRECTV test plan, called for initial monitoring of Northpoint transmitter characteristics such as transmitter on/off status and carrier frequency and bandwidth. Once the key characteristics were determined, the specific DBS systems were set up and tuned to the appropriate transponder in order to observe changes in the DBS signal quality.

The test configuration consisted of three DBS systems. Each of these systems consisted of a DBS antenna, LNB, integrated receiver decoder, and associated hardware. One DBS system was dedicated to monitor the Northpoint transmitter characteristics (*i.e.,* on/off status, carrier frequency, and bandwidth). The remaining DBS systems were used to record signal strength meter changes detected in each specific receiver.

The major difference between these DBS systems was the specific receiver model used for the test. The DIRECTV DBS system consisted of an RCA brand receiver (model DRD 203). The Echostar DBS system consisted of an Echostar series 4000 receiver. Also, the DIRECTV interference measurements used a computer to record signal meter changes every four seconds. Changes in the Echostar signal meter were recorded manually.

DIRECTV calibrated each DBS receiver in order to establish a performance benchmark for each test receiver. The calibration was performed by off pointing the DBS antenna, thereby varying the carrier signal level and recording the carrier power (measured using a spectrum analyzer) and the corresponding signal strength meter reading the appropriate spectrum analyzer power level.[19]

5.3 *Measured Interference Results into DIRECTV BSS Receivers (101°)*

DIRECTV observed interference into DIRECTV receivers receiving signals from a DBS satellite located at 101° W.L. during the Washington, D.C. demonstration. As shown in figure 2.1.4.1-2 (section 2.1.4), these interference measurements were conducted along or near the 167° azimuth bearing from the Northpoint transmitter into DIRECTV DBS receivers located at numerous test sites in the proposed Northpoint coverage area. Upon completion of site surveys, DIRECTV set up DBS systems and performed interference measurements at each site.

5.3.1 Sites and Calibration

Table 5.3.1-1 identifies the test sites where DIRECTV measured interference into DIRECTV DBS receivers receiving signals from 101° W.L. These sites are identified by site numbers along with their approximate distance from the Northpoint USA Today transmit site. The latitude and longitude coordinates were measured using a conventional GPS receiver.

[19] These calibration measurements were performed in a no interference zone. The receiver performance is then used to evaluate the interference impact on the DBS receivers.

DTV Site	Site Name	Distance from NPT Transmitter (km)	Latitude	Longitude
2	Iwo Jima Memorial Site A	0.4	38°53.392	77°04.217
3	110 Frwy (Railroad)	1.62	38° 52.841	77° 03.611
4	110 Frwy (Construction Site)	0.43	38° 52.841	77° 03.611
5	Iwo Jima Memorial Site B	0.59	38°53.29	77°04.101
8	Theodore Roosevelt Island	0.33	38° 53.686	77° 03.95
10	110 Frwy (Jefferson Davis & Marshall)	0.58	38° 53.290	77° 04.101

Table 5.3.1-1: Interference Test Sites for Measurements Using DBS Satellites at 101° W.L.

Figure 5.3.1-1 shows the receiver signal meter performance curve for the DIRECTV test receiver used in the tests reported in this filing. In the D.C. area, this receiver was calibrated for the low information rate mode on transponder 18.

As expected, this receiver's performance looks similar to the typical DBS receiver's performance shown in section 3.3.

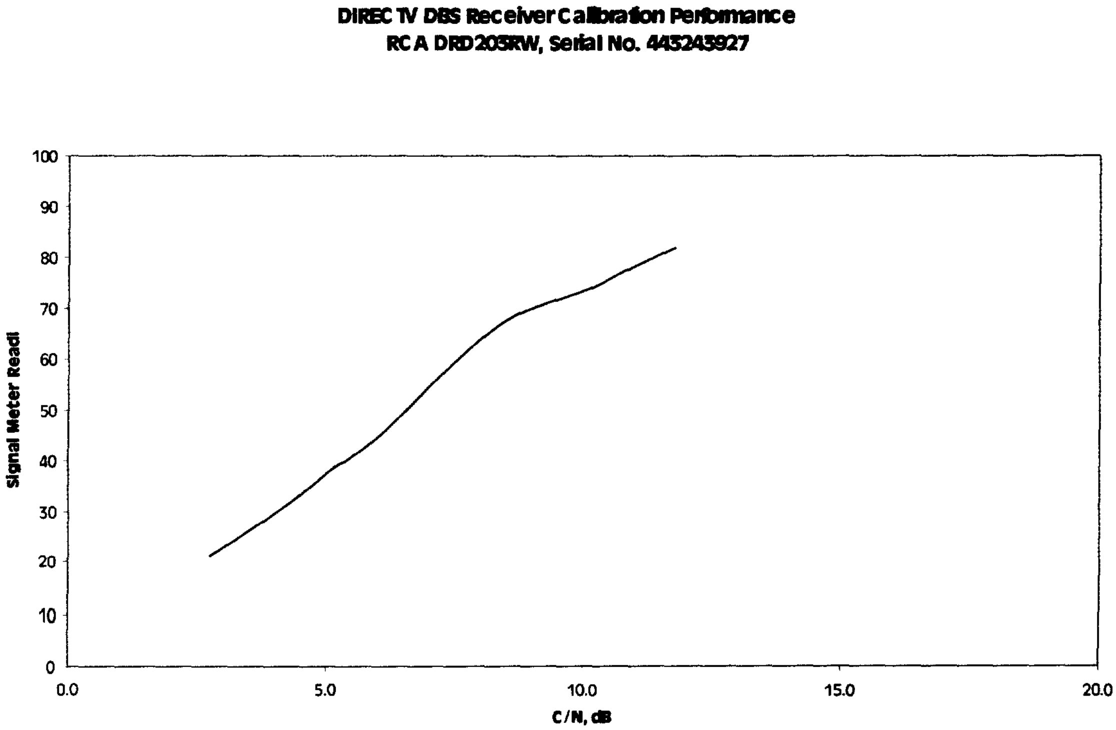

Figure 5.3.1-1: DIRECTV DBS Test Receiver Calibration Curve

Table 5.3.1-2 summarizes the DIRECTV receiver (C/N) degradation as a function of the change in signal meter reading due to added interference. Once the degradation in C/N is determined, the corresponding carrier-to-interfering-noise ratio (C/I) can be calculated. Finally, the calculated increase in DIRECTV's unavailability in the Washington, D.C. area for this carrier to interference ratio is shown in the rightmost column.

For example, the signal meter value of 82 is equivalent to a carrier-to-noise ratio of 11.8 dB. Now if we assume with the Northpoint transmitter turned on, the added interference reduces the DIRECTV signal by three counts (from 82 to 79), the clear-sky margin is reduced by 0.6 dB. This results in an unacceptable degradation in DIRECTV's system availability performance of about 15%. This reduction in the signal-to-noise ratio of the DIRECTV signal can be equated to an equivalent C/I ratio of 20.1 dB.

The calculated availability for this Washington, D.C. link is 99.9399% as shown in Appendix A. When the measured Northpoint interference is included, this link availability is reduced to 99.9307%, which results in a 15.4% increase in unavailability for the DIRECTV service. For comparison purposes, this reduction is greater than the 10% criterion for *all* NGSO-FSS systems.

Signal Count Change	Signal Meter Value	C/N (dB)	C/N degradation (dB)	Calculated C/I (dB)	% Increase in Unavailability
	82	11.8			
-1	81	11.6	0.2	25.2	4.6
-2	80	11.4	0.4	22.0	9.8
-3	79	11.2	0.6	20.1	15.4
-4	78	11.0	0.8	18.5	23.0
-5	77	10.8	1.0	17.5	29.8
-6	76	10.6	1.2	16.6	37.8
-7	75	10.4	1.4	15.9	45.7
-8	74	10.2	1.6	15.2	55.5
-9	73	9.8	2.0	14.1	76.6
-10	72	9.6	2.2	13.6	89.2
-11	71	9.3	2.5	12.9	111.7
-12	70	9.0	2.8	12.2	141.6
-13	69	8.7	3.1	11.6	176.3
-14	68	8.6	3.2	11.4	190.2
-15	67	8.4	3.4	11.1	214.0

Table 5.3.1-2: DIRECTV BSS Test Receiver Calculated C/I Performance

5.3.2 Sample Observation of Interference

Figure 5.3.2-1 is the measured change in signal meter reading for the DIRECTV receiver recorded at the Iwo Jima Memorial (DIRECTV site 5) on September 24, 1999. In this figure, measured signal strength versus time is shown for the DIRECTV BSS receiver. As shown, points A, B and C represent the unshielded test configuration. For this case, the average signal strength value was 80.5. Points D and E represent the shielded test configuration at different times. The average signal strength value for this configuration was 83.5.

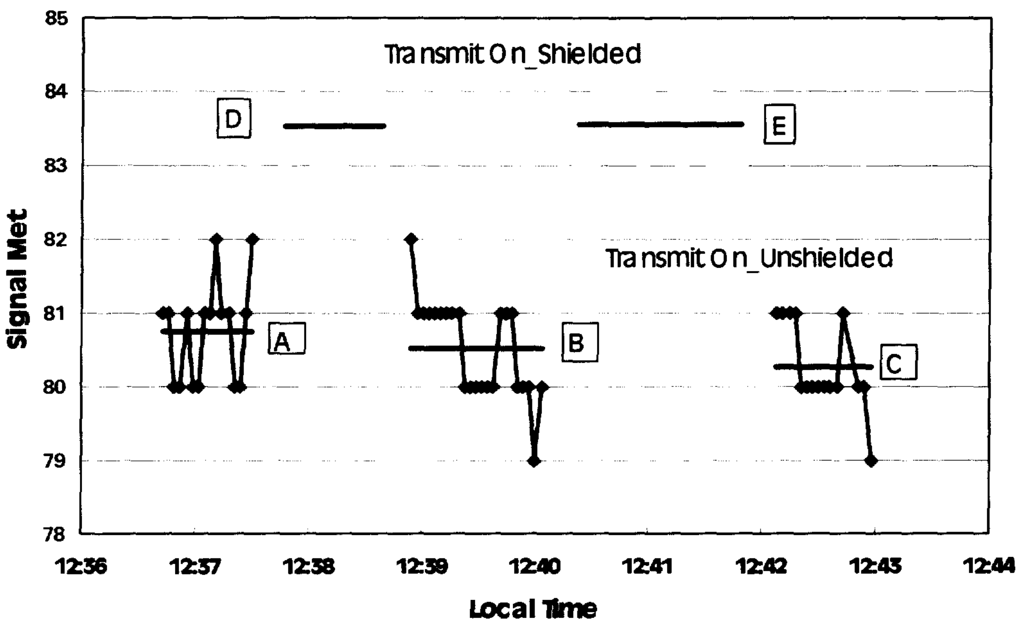

Figure 5.3.2-1: Signal Strength Change at Iwo Jima Memorial (in Washington, D.C.)

First, note the clear step change in clear-sky signal meter readings when interference is introduced. Variations in signal meter readings caused by atmospheric propagation changes are normal, and can be seen here as variations of plus or minus one count in either a shielded or unshielded sequence of data points. However, when interference is either introduced or taken away (change from A to D or D to B), the signal meter shows a clear change in its "baseline." This is the same baseline change evident in Figures 3.4.1.1-1 and 3.4.1.2-1, and indicates a loss in clear-sky margin.

The three count signal meter baseline change seen in the above example equates to an unavailability degradation of about 15%. Clearly then, interference above that allowed for all NGSO-FSS systems was measured into the DIRECTV BSS receiver located at the Iwo Jima Memorial site.

5.3.3 Summary of Interference Observations

Northpoint has erroneously stated that no harmful interference was detected in the Washington, D.C. area. In fact, both Northpoint and DIRECTV detected harmful interference in their observations. This can be seen in Table 5.3.3-1, which summarizes observations taken at both DIRECTV and Northpoint test sites. Note that these are observations of interference into receivers looking only at the 101° W.L DBS satellites. The measured change in signal meter value, along with the calculated increase in DIRECTV's unavailability, is shown.

Site identification is shown in the leftmost column of Table 5.3.3-1. Site numbers that start with "DTV" indicate site numbers and observations taken by DIRECTV. The site numbers correspond with those found in Table 5.3.1-1. Site numbers that start with "NPT" indicate site numbers and observations taken by Northpoint. Some Northpoint observations are included on the table for purposes of comparison. Northpoint results can be found in Table III-6 of Appendix III of the Northpoint Experimental D.C. Report.

Note that in some instances both DIRECTV and Northpoint took observations at very similar or identical locations. These are shown in the table as double row entries.

Site Number	Date	Name	Signal Meter Change	Calc. C/I, dB	Increase In Unavailability
DTV-2	10 Aug 99	Iwo Jima 'A'	-2	22	9.8 %
DTV-3	10 Aug 99	110 Freeway / Railroad	-1	25.2	4.6 %
DTV-4	10 Aug 99	110 Fwy / Construction Site	+1	---	---
NPT-10A	16 Aug 99	Same name	+0.8	---	---
DTV-5	24 Sep 99	Iwo Jima 'B'	-3	20.1	15.4 %
NPT-7A	11 Aug 99	Rt. Marshall and Marshall	-5	17.5	29.8%
DTV-8	4 Aug 99	Theo. Roosevelt Island	0	---	---
NPT-1A	4 Aug 99	Same name	-1.9	22	9.8 %
DTV-10	10 Aug 99	110 Fwy /J. Davis & Mrshll	-1	25.2	4.6 %
NPT-1	14 Aug 99	River Place Apts	-5.1	17.4	30.5%
NPT-3	14 Aug 99	Kennedy Center	-1.6	22.8	8%
NPT-7	4 Aug 99	Arlington Cemetery	-5.6	16.9	34.9%

Table 5.3.3-1: Summary of Interference Impact on DIRECTV's Unavailability

The percent values associated with each test site are either calculated or estimated percent changes in unavailability as derived from reported signal meter changes. The values derived from DIRECTV observations are calculated using the specific signal meter versus C/N calibration curve for the actual DIRECTV test receiver. The values derived from Northpoint observations are estimated based on their filed signal meter change observations and this same calibration curve.

The highest level of interference recorded by DIRECTV was found at DIRECTV's site 5, which was located very close to Northpoint's site 7A. As discussed in Section 5.3.2, DIRECTV recorded a change in signal meter reading of 3 counts. Northpoint reported a 5 count decrease in signal meter reading. Both are very significant, and equate to a 15% or higher degradation in unavailability.

Northpoint observed the equivalent of an approximate 30% change in unavailability at their River Place Apartments site (NPT-1). Northpoint also initially measured high levels of interference at their Arlington Cemetery site (NPT-7). However, as discussed in Section 3.4.2, and as seen in Table III-6 of Appendix III of the Northpoint Experimental D.C. Report, the observed change in signal meter readings inexplicably went down over time at this site. Northpoint observed no change in signal meter reading on August 23, and no change is seen in Figure 12 on page 22 of this same report.

Levels equivalent to about a 10% change were seen by DIRECTV at site DTV-2 and by Northpoint at site NPT-1A.

As confirmed by its own data, Northpoint's transmissions were affecting the clear-sky margin and availability performance of DIRECTV receivers.

DIRECTV adds a final word here on Northpoint's explanation of the high interference levels manifested in the data from its D.C. testing. Northpoint has taken the position that while such levels may have been observed, the "averaged" interference measurements reflect only a slight degradation of DBS signal reception. This position is wholly untenable from a customer service point of view, given that DBS is a mass-market consumer service. DBS is a ubiquitous service that must be protected across its service area, not merely portions of it. Individual subscribers who experience significant Northpoint interference will not be comforted by the fact that other consumers contained within Northpoint's averaged numbers may not be experiencing similar interference.[20]

5.3.4 Data Discrepancies

Northpoint and DIRECTV have measured similar but not equal levels of interference at several sites. This includes the Theodore Roosevelt Island site and the Iwo Jima 'B' site. These differences are somewhat to be expected from two different groups that use differing test procedures and make their observations on different days. Furthermore, the beam tilt and the transmit power level of the Northpoint antenna were not independently verified, and may

[20] *See also* Echostar Preliminary Report at 1, 19.

have led to lower than predicted measurements at some sites and higher than predicted measurements at other sites. Some of this variability could be reduced through the use of identical test procedures and a guarantee of fixed and unchanging transmission parameters.

For example, Northpoint interference data measured on the August 4, 1999 at the Theodore Roosevelt Island site (Site 1A) show a change of about -1.9 in the DBS signal meter due to interference. DIRECTV did not measure any significant change in signal meter readings at this site. It should be noted that data collection was seriously impeded at the site due to the heavy foliage and the inaccessibility of the Island.

Also, Northpoint's interference measurements at the Arlington Cemetery (site 7) show a -5.6 change in the signal meter value on August 4, 1999. Northpoint repeated these measurements at the same site over several days. As shown in Northpoint's data,[21] the signal meter changed from -5.6 (August 4) to -2.2 (August 12) and to 0.1 (August 23). This site was used for Northpoint's "Hurricane Floyd" observations, and this change in signal meter reading over time was also discussed in Section 3.4. Clearly Northpoint's interference measurements seem to suggest that transmit parameters were varied, making results difficult to compare and casting serious doubt on their conclusions regarding operation of the Northpoint system in rain.

It is important in any future testing to: use test procedures that provide consistent and reliable results; have a guarantee of fixed and unchanging transmission parameters; and test in areas with reasonable physical access to all parts of the interference zone.

5.4 *Measured Interference into Echostar BSS Receivers (61.5°)*

DIRECTV also made interference measurements for Echostar BSS receivers pointed at a DBS satellite located at 61.5 W.L. As shown in Figure 2.1.4.1-2 (section 2.1.4), these interference measurements were conducted along or near the 108° azimuth bearing from the Northpoint transmitter.

5.4.1 Sites and Calibration

Table 5.4.1-1 identifies the test sites where DIRECTV measured interference into Echostar DBS receivers. The test site coordinates along, with approximate distances from the Northpoint USA Today transmit site, are identified.

[21] Northpoint Experimental D.C. Report at Appendix III, Table III-6.

DIRECTV Site	Site Name	Distance from NPT Transmitter (km)	Latitude	Longitude
4	110 Frwy (Construction Site)	0.43	38° 52.841	77° 03.611
6	Ericsson Memorial (Shoreline)	2.65	38° 52.872	77° 02.580
7	Ericsson Memorial (Polo Field)	2.31	38° 53.169	77° 02.631
8	Theodore Roosevelt Island	0.33	38° 53.686	77° 03.95
9	Kennedy Center	1.2	38°53.29	77°04.101

Table 5.4.1-1: Interference Test Sites into DBS Satellite at 61.5° W.L

In the D.C. area, calibration performance for this particular Echostar BSS test receiver (model 4000) was measured on transponder 18. As shown in Figure 5.4.1-1, Echostar's BSS test receiver calibration performance has the same general characteristics as the typical curve shown in Figure 3.1-2.

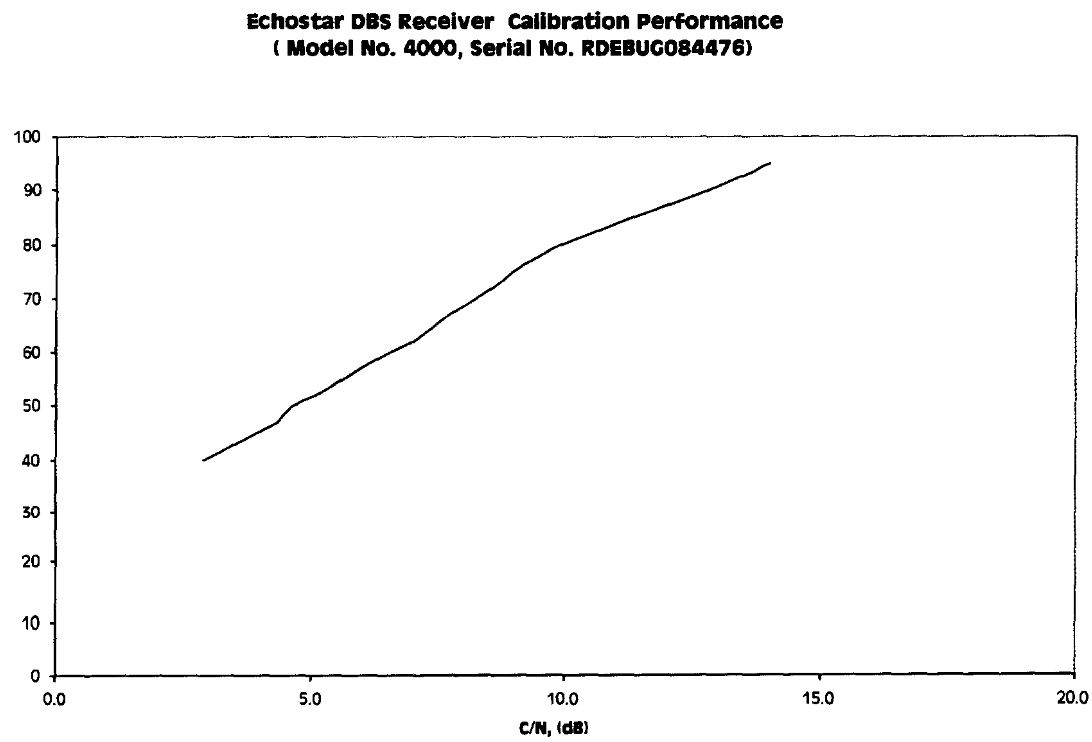

Figure 5.4.1-1: Echostar BSS Receiver Calibrated Performance

Table 5.4.1-2 summarizes the BSS receiver carrier-to-noise ratio (C/N) degradation as a function of the change in signal meter. It also includes the corresponding C/I ratio.

Count Change	Signal Strength	C/N	C/N Degradation (dB)	Calculated C/I (dB)
	94	13.8		
-1	93	13.5	0.3	26.7
-2	92	13.3	0.5	22.9
-3	91	13.0	0.8	21.4
-4	90	12.8	1.0	19.8
-5	89	12.5	1.3	18.9
-6	88	12.2	1.6	17.8
-7	87	11.9	1.9	16.8
-8	86	11.7	2.1	16.0
-9	85	11.4	2.4	15.5
-10	84	11.1	2.7	14.8
-11	83	10.8	3.0	14.2
-12	82	10.5	3.3	13.6
-13	81	10.3	3.6	13.0
-14	80	10.0	3.8	12.6

Table 5.4.1-2: Summary of Echostar's Calculated C/I Performance

5.4.2 Sample Observation of Interference

DIRECTV repeatedly measured harmful interference into an Echostar receiver at the Memorial/Polo Field Site. Initial measurements performed on August 11 and 12 observed a -3 and -4 count change in the Echostar receiver's signal strength meter reading for transponder 18. On August 11, the signal strength reading changed from 93 (receiver shielded from interference) to 90 (shield removed), and on August 12 the change was from 94 to 90.

Further investigation showed that the actual interference levels were significantly higher. The earth station antenna configuration used for the initial measurements had an Echostar antenna and a DIRECTV antenna mounted side by side on a common platform. However, for the interference geometry at the Ericsson Memorial/Polo Field site, the DIRECTV antenna inadvertently shielded the Echostar antenna from Northpoint's transmissions.

Subsequent tests, which were performed with the DIRECTV antenna removed from the antenna mount, measured substantially higher levels of interference. On September 8, the signal strength meter reading changed from 94 (shielded) to 86 (unshielded), an eight count reduction in the signal strength. And when the experiment was repeated yet again on September 24, the signal strength again changed from 94 (shielded) to 86 (unshielded). The eight-count reduction in signal strength equates to a 2.1 dB reduction in the carrier-to-noise ratio and a C/I under clear-sky conditions of approximately 16 dB. Per calculations performed by Echostar, this would result in an 84% increase in unavailability.[22]

5.4.3 Summary of Observations

A summary of DIRECTV and Northpoint observations of interference into receivers looking at the Echostar satellite at 61.5° W.L. can be seen in Table 5.4.3-1. The measured change in signal meter value, along with an estimated increase in Echostar's unavailability, is shown. The estimated unavailability is based on information supplied by Echostar in its October, 1999 filing.[23]

Site identification is shown in the leftmost column of Table 5.4.3-1. Site numbers that start with DTV indicate DIRECTV sites, and the observations were taken by DIRECTV. The site numbers correspond with those found in Table 5.4.1-1. Site numbers that start with NPT indicate Northpoint sites, and the observations were taken by Northpoint. Not all observations by Northpoint or DIRECTV are shown in the table. This table is intended as an overview of typical results. Complete Northpoint results can be found in Table III-6 of Appendix III of the Northpoint Experimental D.C. Report.

Note that in some instances both DIRECTV and Northpoint took observations at very similar or identical locations. These are shown in the table as double row entries.

The increase in unavailability values associated with each test site are estimated percent changes in unavailability as derived from reported signal meter changes.

The values derived from DIRECTV observations are estimated using the specific signal meter versus C/N calibration curve for the actual Echostar test receiver to provide a C/I value. The impact on unavailability is then estimated using the typical curve found in Figure 3.2-1.

The increase in unavailability values derived from Northpoint observations are estimates based on their filed signal meter change observations. Echostar has not supplied a calibration curve of their Echostar test receiver. DIRECTV has in its place used the calibration curve found in Figure 5.4.1-1 to derive an estimated

[22] Echostar Preliminary Report at 7.

[23] *Id.*

C/I value. The impact on unavailability is then estimated using the typical curve found in Figure 3.2-1.

Site Number	Date	Name	Signal Meter Change	Calc. C/I, dB	Increase In Unavailability
DTV-4	10 Aug 99	110 Fwy / Construction Site	0	---	---
NPT 10A	16 Aug 99	Same Name	-2.6	22	~10 %
DTV-6	11 Aug 99	Ericsson Mem. / Shoreline	-3	21.4	~13 %
DTV-7	11 Aug 99	Ericsson Mem. / Polo Field	-3*	21.4	~13 %
	12 Aug 99		-4*	19.8	~17 %
	8 Sep 99		-8	16	84 %
	24 Sep 99		-8	16	84 %
DTV-8	4 Aug 99	Theo. Roosevelt Island	0	---	---
NPT-1A	4 Aug 99	Same name	-4.4	19.2	~20 %
DTV-9	12 Aug 99	Kennedy Center	0	---	---
NPT-3	14 Aug 99	Same name	-0.7	---	---

* Partially shielded by test equipment (see section 5.4.2)

Table 5.4.3-1: Summary of Interference Impact into Echostar's BSS Receivers (In Washington, D.C. area)

The highest level of interference was measured at the Ericsson Memorial/Polo Field location. These results were discussed in some detail in Section 5.4.2. The estimated degradation in unavailability is over 80% at this location.

Lower but still very significant levels of interference were seen by DIRECTV at the Ericsson Memorial/Shoreline site, and by Northpoint at the 110 Freeway / Construction site and at the Theodore Roosevelt island site. Observations at all of these sites show interference levels above those allowed for all NGSO-FSS systems combined.

5.5 *Comparison of DIRECTV Field Measurements with Analytical Predictions*

The NSMA[24] Over the Horizon (OH) loss propagation model, software coded by Radio Dynamics, was used to make predictions of radio field strengths and interference in the 12.2 - 12.7 GHz band at specific receive sites in the Washington, D.C. area. A computer program of the OH loss model used the transmitter coordinate locations, antenna heights and the antenna horizon gain patterns supplied by Northpoint in their public filings to the FCC.

[24] NSMA is the National Spectrum Managers Association, and a copy of the OH Loss Model can be obtained through their web site: www.nsma.org.

This analysis was used primarily to determine the size of interference zones around Northpoint transmitters. Figure 5.5-1 displays the results of one such analysis. The figure shows calculated interference zones into DIRECTV receivers from the Northpoint USA Today transmitter during the Washington, D.C. demonstration. The analysis assumed a Northpoint antenna transmit azimuth of 113°, and calculated interference into DIRECTV receivers looking at the 101° W.L. DIRECTV constellation of satellites.

In this figure, the yellow region represents interference levels above that allowed for *one* NGSO-FSS systems (unavailability degradation of 2.86%); the green region represent interference levels above that allowed for *all* NGSO-FSS systems combined (unavailability degradation of 10%).

For these calculations, the coordinates used for the USA Today transmit site were 77-04-11.0W and 38-053-39.0N. The antenna height was taken to be 453 feet above ground level (AGL). The Northpoint antenna pattern was obtained from Northpoint filings, which described an antenna with a 110 horizontal beamwidth and 17.5 vertical beamwidth. The blue line at the top left corner of the green region represents the pointing direction of the Northpoint transmitter. The transmitter itself is located at the upper end of this blue line.

The victim DBS receive antenna was assumed to be 10 meters off the ground. A DBS receive antenna gain pattern measured in the horizontal plane with a fixed elevation angle of 40 was used.

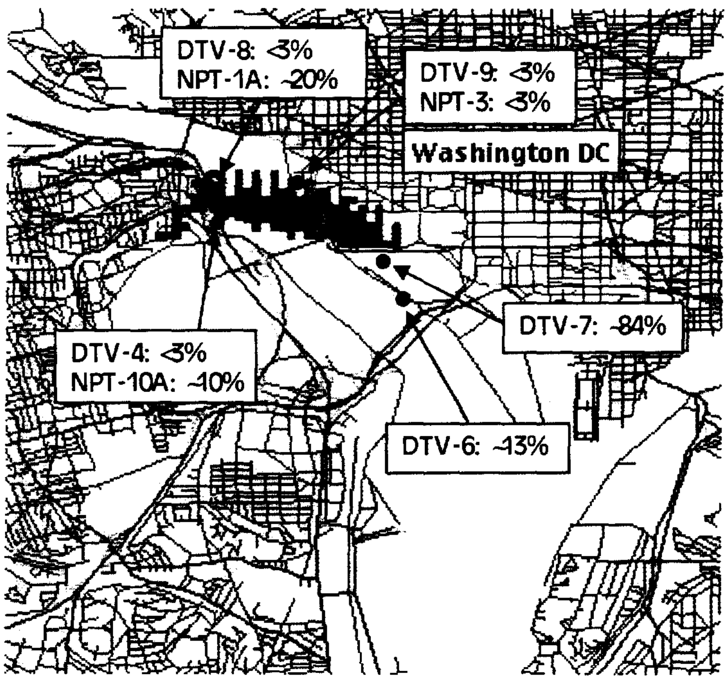

Figure 5.5-1: Predicted Interference from Northpoint USA Today site (113° azimuth) into DIRECTV BSS Receivers at 101°

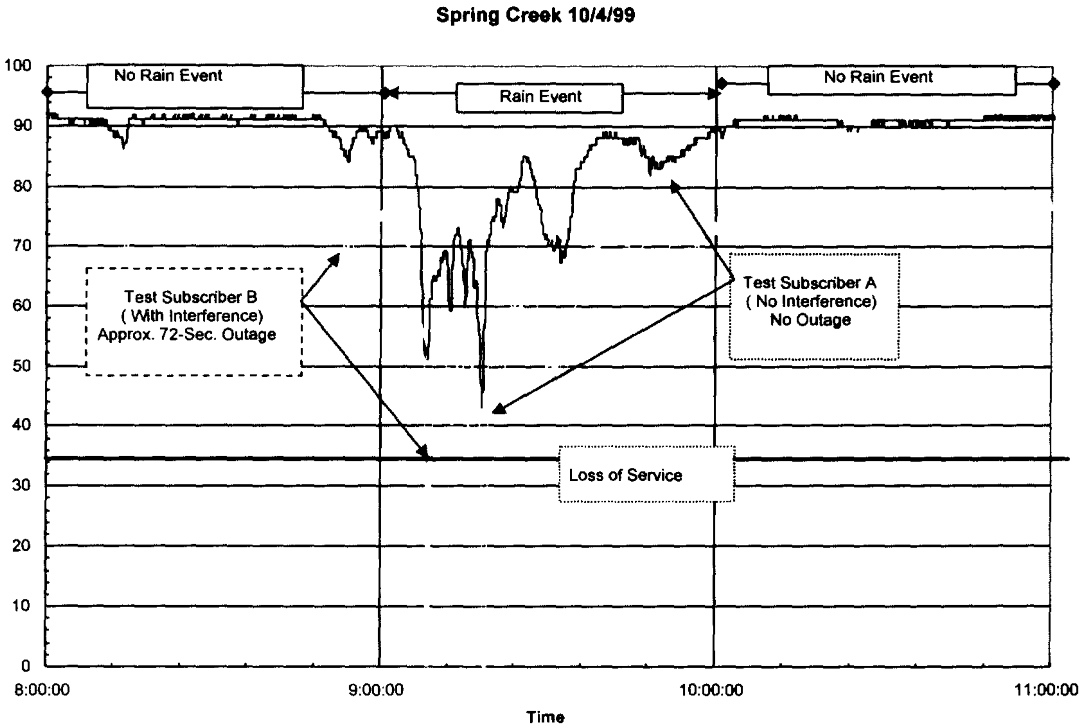

Figure 3.4.1.2-1: New York Rain Event, October 4, 1999

Figure 3.4.1.2-1 shows the recorded performance of a rain event (with and without interference) during a three-hour rain event on October 4, 1999. From observations of the clear-sky signal meter readings and from the calibration figures for this receiver, it appears however that the C/I ratio was near 13.7 dB on this day. As before, test Subscriber A receiver (IRD1) was identical to test Subscriber B receiver (IRD2). Test subscriber A receiver (IRD1) had no interference. Test subscriber B receiver (IRD2) had added noise equivalent to a C/I of about 13.7 dB

Here, Receiver A again has a nominal clear-sky signal meter value of approximately 92, corresponding to a C/(N+I) of about 16 db. Again note that the added interference has degraded the clear-sky C/(N+I) of Receiver B, whose signal meter level is now around 78.

An outage (loss of signal) again occurs when the signal meter drops below approximately 34, corresponding to a C/N below about 6 dB. As clearly demonstrated Receiver B (with added interference) suffered rain fades in this event while Receiver A suffered no rain fades.

3.4.1.3 Summary of New York Rain Observations